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Growth, Food Habits, and the Relative Effectiveness of Stocking Rainbow Trout (Salmo gairdneri) in South-Central South Dakota

Kenneth C. Clodfelter

GROWTH, FOOD HABITS, AND THE RELATIVE EFFECTIVENESS OF STOCKING RAINBOW TROUT (*Salmo gairdneri*) IN SOUTH-CENTRAL SOUTH DAKOTA

BY

KENNETH C. CLODFELTER

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IN SOUTH-CENTRAL SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Dr. Charles G. Scalet — Date
Thesis Adviser

Dr. Charles G. Scalet, Head — Date
Department of Wildlife and
Fisheries Sciences

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OF STOCKING RAINBOW TROUT (*Salmo gairdneri*)

IN SOUTH-CENTRAL SOUTH DAKOTA

Abstract

KENNETH C. CLODFELTER

The effectiveness of stocking rainbow trout (*Salmo gairdneri*) in 47 selected stock ponds in south-central South Dakota was analyzed in 1977 and 1978. Rainbow trout were captured in 31 (66.0%) ponds during the study. Twenty-five of the 31 ponds (80.6%) appeared to have excellent rainbow trout populations. Rainbow trout stocked in ponds with a resident largemouth bass (*Micropterus salmoides*) population had poor survival.

The growth rates and condition factors for 93 and 463 rainbow trout in 1977 and 1978, respectively, were excellent. The average total length for age-groups I and II rainbow trout in 1977 was 195 and 224 mm, respectively. The values for age-groups I, II, III, and V rainbow trout in 1978 were 184, 290, 366, and 499 mm, respectively. The average coefficient of condition value for all rainbow trout in 1977 was 1.04 and 1.07 for all trout in 1978.

Stomachs were removed from 463 rainbow trout in 1978. Hemipterans and gastropods were the dominant food organisms eaten. Other organisms frequently consumed were coleopterans, dipterans, odonates, and cyprinids. Odonates and cyprinids were more frequently consumed by larger trout.

The maximum surface temperatures recorded were 26.0 C in 1977 and 28.5 C in 1978. All ponds contained water with temperatures and dissolved oxygen levels within the reported tolerance ranges of rainbow trout. Several ponds, however, contained marginal levels and may have been responsible for our failure to capture rainbow trout in 16 ponds.

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INTRODUCTION

Most of the rainbow trout (Salmo gairdneri) fishery in South Dakota is centered in the Black Hills; however, scattered throughout the rest of the state are numerous ponds which support rainbow trout populations. The South Dakota Department of Game, Fish and Parks began stocking rainbow trout in non-Black Hills ponds in 1957. Between 1974 and 1978 over 700,000 rainbow trout were stocked in 272 ponds, many in south-central South Dakota. Rainbows are usually stocked at sizes ranging from 37.5 - 112.5 mm and at stocking rates of 750 - 1,250 fish/ha (R. Hanten pers. comm.). Specific pond size and depth conditions have to be met before rainbow trout can be stocked.

Casual observations have indicated that some rainbow stockings in South Dakota ponds have resulted in excellent populations, while others have been unsuccessful. There have, however, been no detailed studies to determine growth, food habits, or stocking success for rainbow trout in these prairie ponds.

South Dakota has approximately 88,000 stock ponds (Ruwaldt et al. 1979). Many of these ponds are stocked with the largemouth bass (Micropterus salmoides) - bluegill (Lepomis macrochirus) combination.

Stocking rainbow trout in some ponds has certain advantages. They can provide a recreational fishery. They can be fished the winter after stocking, and rainbow trout do not normally reproduce in ponds so less management is needed to maintain a "balanced" fish population.

The objectives of this study were: 1) to ascertain the growth and condition of rainbow trout stocked in south-central South Dakota ponds, 2) to analyze the food habits of the trout, and 3) to evaluate the relative effectiveness of the pond trout stocking program.

STUDY AREA

Climate

South-central South Dakota has a continental climate with hot summers, cold winters, and rapid temperature fluctuations. The mean annual precipitation varies from 35-48 cm. The mean annual temperature varies from 7.2 - 8.9 C (Spuhler et al. 1971). The mean annual evaporation from shallow lakes in south-central South Dakota is 124 cm (Meyer 1942).

Study Ponds

Many stock ponds were built as a result of the range program initiated in 1937 by the United States Department of Agriculture (USDA), to furnish additional livestock watering areas (Bue et al. 1952). In south-central South Dakota, stock ponds are generally constructed by placing an earthen dam across a natural drainage.

Vegetation and Land Use

The Pierre Hills and Coteau du Missouri, where the study ponds were located, are mixed grass prairies with western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), needle-and-thread (*Stipa comata*), and green needlegrass (*S. viridula*) being the predominant native vegetaion (Johnson and Nichols 1970). Rangeland or pasture constituted approximately 70 - 80% of the land use in the study area from 1970 - 1975 (Westin and Malo 1978).

MATERIALS AND METHODS

Mail Survey

The South Dakota Department of Game, Fish and Parks stocking records in Pierre were searched in June 1977 for ponds in south-central South Dakota that had been stocked with rainbow trout in the previous five years. Fifty-four ponds were located which met this criteria. Pond owners were sent a letter informing them of the research study and asking for permission to use ponds as study sites. Also provided was a self-addressed envelope and a survey questionnaire (Fig. 1).

Physicochemical Evaluation

Water samples were taken between 19 July and 11 October 1977 and between 16 May and 10 August 1978. One sample station at the deepest area in each pond was selected. This area was determined using a weighted line marked at 0.5 m intervals. Water samples were collected at the surface and at 1 or 2 m intervals with a Kemmerer water bottle at each pond so that at least three depths were represented. Ponds were only sampled once. Analysis of pH, total hardness, and total alkalinity were conducted in the field using the procedures prescribed in Standard Methods of Water and Wastewater Analysis (APHA 1971). Dissolved oxygen concentrations were determined using the modified azide-Winkler method (Lind 1974). Conductivity, salinity, and water temperature were measured in the field with a YSI (Yellow Springs Instrument Company) Model 33 meter.

Figure 1. Survey questionnaire mailed to pond owners in June 1977 to ascertain the status of South Dakota ponds stocked with rainbow trout (Salmo gairdneri).

Survey on Trout Ponds

1. How many ponds do you have stocked with rainbow trout?

   ____

2. Has the water maintained approximately the same level since stocking? ______________________________

3. Have you noticed any fish dead around the ponds bank?

   ____

4. Have you seen or caught any rainbow trout in the last six months? ______________________________

5. Do you think there are rainbow trout still in the ponds?

   ____

6. May we sample your pond for this research project?

   ____

Comments:

Fish Sampling Devices

Gill nets were the principle means of fish collection. Six different mesh size nylon gill nets 30.5 m long, 2.4 m deep, with bar meshes ranging from 19.0 - 76.0 mm were used to minimize gear selectivity (Ricker 1949; Regier and Robson 1967). Gill nets were fished until at least 15 rainbow trout were captured or for one night of netting. Sample time varied among ponds. A seine 26.5 m long, 3.7 m deep, with a 12.7 mm mesh, and a 1.8 m^3 bag was used for capture at times as was hook-and-line angling. All fish were weighed to the nearest gram on a Chatillion scale and measured to the nearest millimeter in total length.

Fish Stomach Content

Stomachs were removed only in 1978 where they were excised and wrapped in cheesecloth bags with an identification number given to each. Stomachs were preserved immediately in 10% formalin to prevent continued digestion and decomposition (Ball 1948; Turner 1955). Stomach content analysis was conducted in the laboratory. Content identification was accomplished using Edmondson (1966), Eddy (1969), and Pennak (1978). All contents of the digestive tract (esophagus to pylorus) were enumerated. The volumes of larger food organisms were measured by water displacement in a graduated cylinder. The volumes of smaller organisms were determined with a syringe volumetric measuring device similar to that recommended by Inglis and Barstow (1960). Stomach contents were analyzed individually and were reported in four different manners. The first three — frequency of occurrence, percentage, and percentage volume — all contain biases which limits the usefulness of any one singly (Windell 1971). The fourth technique was a relative importance index ($a(RI_a)$) (Cox 1976; George and Hadley 1979). The formula used to calculate this index was:

$$AI_a = \%\text{ frequency of occurrence} + \%\text{ total number} + \%\text{ total volume for food item } a;$$

Where: AI_a = absolute importance index

$$RI_a = 100\ AI_a \ / \sum_{a=1}^{n} AI_a$$

Where: RI_a = relative importance index

n = number of different food items

Fish Growth Analysis

Trout scales were used to age and back-calculate lengths at the time of earlier annuli formation. The scale method of age and growth determination has been shown to be valid for rainbow trout (Bhatia 1932; Greeley 1933; Alvord 1953).

Scales were removed from the right side of the body, just above the lateral line and below the anterior origin of the dorsal fin to minimize the number of regenerated scales collected (Drummond 1966). The scales were impressed on clear cellulose acetate slides and examined on an Eberbach projector.

The computer program SHAD (Mayhew 1973) was used to analyze growth data. Class intervals of 15 or 25 mm were assigned rainbow trout for obtaining a length-frequency distribution. The size of the interval assigned depended on the number and size of the rainbow trout.

This was necessary to eliminate the number of small groups. Average coefficient of condition (K_{TL}) for each class interval was calculated using the formula:

$$K_{(TL)} = \frac{W \times 10^5}{L^3}$$

Where: W = weight in grams

L = total length in millimeters

and: 10^5 is a factor to bring the value of K near unity

Total length to each annulus was back calculated for each age-group by the formula:

$$L_{ij} = \frac{\bar{S}_{ij}}{\bar{S}_i} L_j$$

Where: L_{ij} = length of fish when annulus j was formed

L_j = length of fish at time of scale sampled

$\bar{S}_{ij}$ = mean radius of annulus at L_j

$\bar{S}_i$ = total scale radius

i = age

j = annulus

Also analyzed were length-weight and body-scale regressions.

RESULTS AND DISCUSSION

Mail Survey

Survey replies eliminated 7 ponds because of low water levels. Forty-seven study ponds were used, all were constructed after 1964 (Fig. 2). All study ponds except 1 were less than 3.2 ha in surface area; maximum depths ranged from 3.5 - 8.0 m. Appendix 1 contains the names and addresses of pond owners who cooperated in this study.

Age and Growth

Rainbow Trout Growth Analysis

Scales were removed from 93 rainbow trout taken from 8 ponds in 1977 and 463 rainbow trout taken from 29 ponds in 1978. Stocking dates were available so all were known age fish which ranged in age from age-group I to age-group V. No pond contained age-group IV rainbow trout.

In July and August 1977, 58 age-group I fish from 5 ponds averaged 293 mm in length; age-group II rainbow trout from 3 ponds averaged 304 mm (Table 1).

Between May and August 1978, 342 age-group I rainbow trout were sampled from 20 ponds; their lengths averaged 281 mm. Thirty-two age-group II rainbow trout were sampled from 6 ponds; their lengths averaged 360 mm. Seventy-six age-group III rainbow trout were sampled from 5 ponds; their lengths averaged 431 mm. Seventeen age-group V rainbows were sampled from 1 pond; average length was 570 mm (Table 2). The average total length of rainbows for age-group I in 1977 and 1978 combined was 283 mm; age-group II for both years combined averaged 331 mm (Table 3).

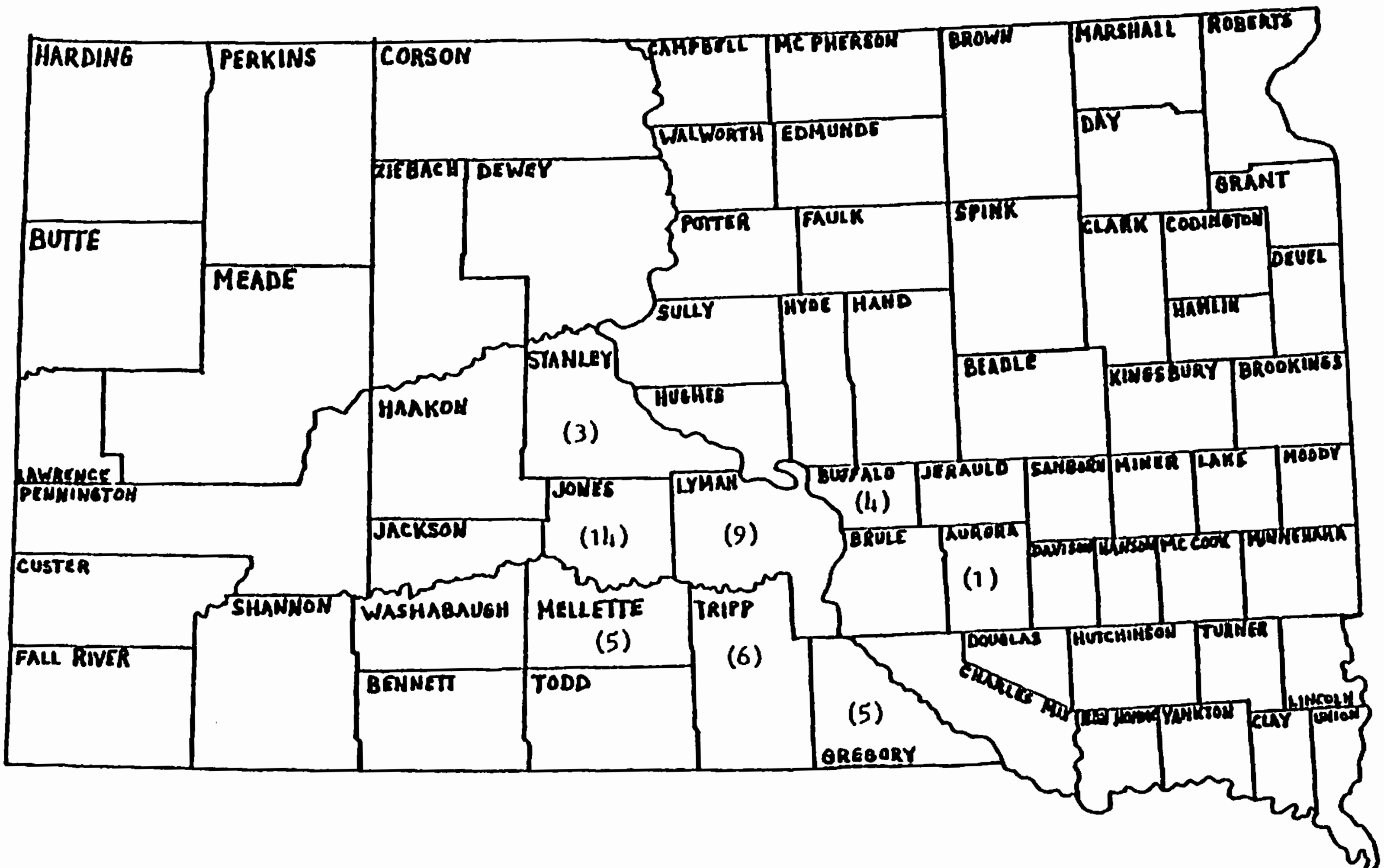

Figure 2. Counties and numbers (in parenthesis) of south-central South Dakota ponds used to determine growth, condition, and food habits of stocked rainbow trout (Salmo gairdneri).

Table 1. Length-frequency distribution and average coefficient of condition (K_{TL}) for all rainbow trout (*Salmo gairdneri*) sampled from 8 stock ponds in south-central South Dakota, summer 1977.

Size-class (mm)	Age-group I		Age-group II	
	Fish number	$K_{(TL)}$	Fish number	$K_{(TL)}$
183-197	2	1.18		
198-212				
213-227				
228-242	8	1.10		
243-257	5	1.08		
258-272	3	0.95		
273-287	4	0.99	11	1.04
288-302	8	0.99	13	1.04
303-317	8	0.98	6	1.05
318-332	10	1.04		
333-347	7	0.97	1	1.28
348-362	3	0.95		
363-377			2	0.95
378-392			2	1.12
TOTAL NUMBER	58		35	

Table 2. Length-frequency distribution and average coefficient of condition (K_{TL}) for all rainbow trout (*Salmo gairdneri*) sampled in 29 stock ponds in south-central South Dakota, summer 1978.

Age-group I			Age-group II			Age-group III			Age-group V		
Size-class (mm)	F[a]	(K_{TL})	Size-class (mm)	F[a]	(K_{TL})	Size-class (mm)	F[a]	(K_{TL})	Size-class (mm)	F[a]	(K_{TL})
200-214	4	1.07	308-314	2	1.06	343-367	4	0.99	491-515	3	1.23
215-229	26	1.05	315-329	3	1.05	368-392	5	1.13	516-540	2	1.06
230-244	52	1.03	330-344	9	1.04	393-417	12	1.14	541-565	2	0.75
245-259	53	1.05	345-359	6	1.04	418-442	25	1.13	566-590	5	1.11
260-274	59	1.03	360-374	6	1.06	443-467	20	1.07	591-615	3	0.94
275-289	32	1.05	375-389	2	0.90	468-492	8	1.17	616-640		
290-304	26	1.04	390-404	2	1.10	493-517	2	1.25	641-665	2	1.10
305-319	24	1.07	405-419								
320-334	22	1.10	420-434								
335-349	18	1.20	435-449	1	1.02						
350-364	10	1.10	450-464								
365-379	6	1.22	465-479								
380-394	3	1.09	480-494	1	0.95						
395-409	4	1.25									
410-424	2	1.26									
425-439											
440-454	1	1.37									
TOTAL NUMBER	342			32			76			17	

[a]Number of fish

Table 3. Length-frequency distribution and average coefficient of condition (K_{TL}) for age-group I and age-group II rainbow trout (*Salmo gairdneri*) for 1977 and 1978 combined.

Age-group I			Age-group II		
Size-class (mm)	Fish number	(K_{TL})	Size-class (mm)	Fish number	(K_{TL})
185-199	2	1.18	270-284	11	1.04
200-214	4	1.07	285-299	13	1.04
215-229	26	1.05	300-314	8	1.05
230-244	60	1.04	315-329	3	1.05
245-259	58	1.05	330-344	10	1.06
260-274	62	1.03	345-359	6	1.04
275-289	36	1.04	360-374	8	1.03
290-304	34	1.03	375-389	4	1.01
305-319	32	1.05	390-404	2	1.10
320-334	32	1.08	405-419		
335-349	25	1.14	420-434		
350-364	13	1.07	435-449	1	1.02
365-379	6	1.22	450-464		
380-394	3	1.09	465-479		
395-409	4	1.25	480-494	1	0.95
410-424	2	1.26			
425-439					
440-454	1	1.37			
TOTAL NUMBER	400			67	

Coefficient of condition values were determined by Student's t-test to be significantly lower ($P < 0.05$) for age-group I rainbow trout in 1977 than in 1978. Condition values in 1977 ranged from 0.95 - 1.18, while values in 1978 ranged from 1.03 - 1.37. Wales (1946) considered condition values of 1.00 - 1.08 to be satisfactory for rainbow trout. All size-classes for age-group I rainbow trout in 1978 had condition values greater than the condition value 1.00 (Table 2). The condition values for age-group II rainbow trout exhibited no significant difference ($P < 0.05$) between 1977 and 1978. Condition values for both years combined indicated that the fish were in excellent condition (Tables 1 and 2). The values in 1978 for age-group III rainbow trout ranged from 0.99 - 1.25. Values for 5 of the 7 size-classes had values greater than 1.08 (Table 2). Values for age-group V rainbow trout in 1978 were highly variable ranging from 0.75 - 1.23 but 4 of the 6 size-classes were equal or greater than the value reported satisfactory for rainbow trout.

Condition values for age-group II rainbow trout were significantly larger (t-test, $P < 0.05$) than condition values of age-group I rainbow trout in 1977. Sigler (1953) reported that the condition values of rainbow trout in Utah also increased with an increase in size or age.

Scheffe's test for all possible comparisons of means was used to compare condition values of the different age-group and size-classes in 1978. Only condition values for age-group III were found to be significantly different (Scheffe's test, $P < 0.05$) from the other age-groups.

The mean condition values of 4 size-classes were compared for 1978. The size-classes were 200 - 304 mm, 305 - 394 mm, 395 - 491 mm, and trout greater than 492 mm. Size-class 395 - 491 mm was significantly different (Scheffe's test, $P < 0.05$) than the other size-classes. When the mean condition values for both years were combined into 5 size-classes the size-classes were 185 - 259 mm, 260 - 334 mm, 335 - 409 mm, 410 - 484 mm, and trout greater than 485 mm. Only size-class 410 - 484 mm was significantly different (Scheffe's test, $P < 0.05$).

The average condition value for all rainbow trout combined in 1977 was 1.04 (Table 1), while the condition value for all fish combined in 1978 was 1.07 (Table 2). The average condition values for 1977 and 1978 were slightly less than the value (1.12) Haskell (1959) reported for hatchery trout in New York and the value (1.15) Stocek and McCrimmon (1965) reported for small Ontario lakes. The values, however, indicated that the trout were in good condition.

Length-weight Relationship

The length-weight relationship for all rainbow trout captured in the summer of 1977 was calculated by the least-squares regression. The regression $\log (W) = -4.6045 + 2.8441 \log (L)$ ($N = 93$); where W = weight in grams and L = length in millimeters (Fig. 3) was derived with a multiple coefficient of determination $r^2 = 0.96$ ($P < 0.01$, $F = 2001.21$, 1/91 df).

The length-weight relationship for all rainbows captured in the summer of 1978 was the regression $\log (W) = -5.0259 + 3.0204 \log (L)$ ($N = 400$). The multiple coefficient for determination was $r^2 = 0.96$ ($P < 0.01$, $F = 9966.64$, with 1/398 df) (Fig. 4).

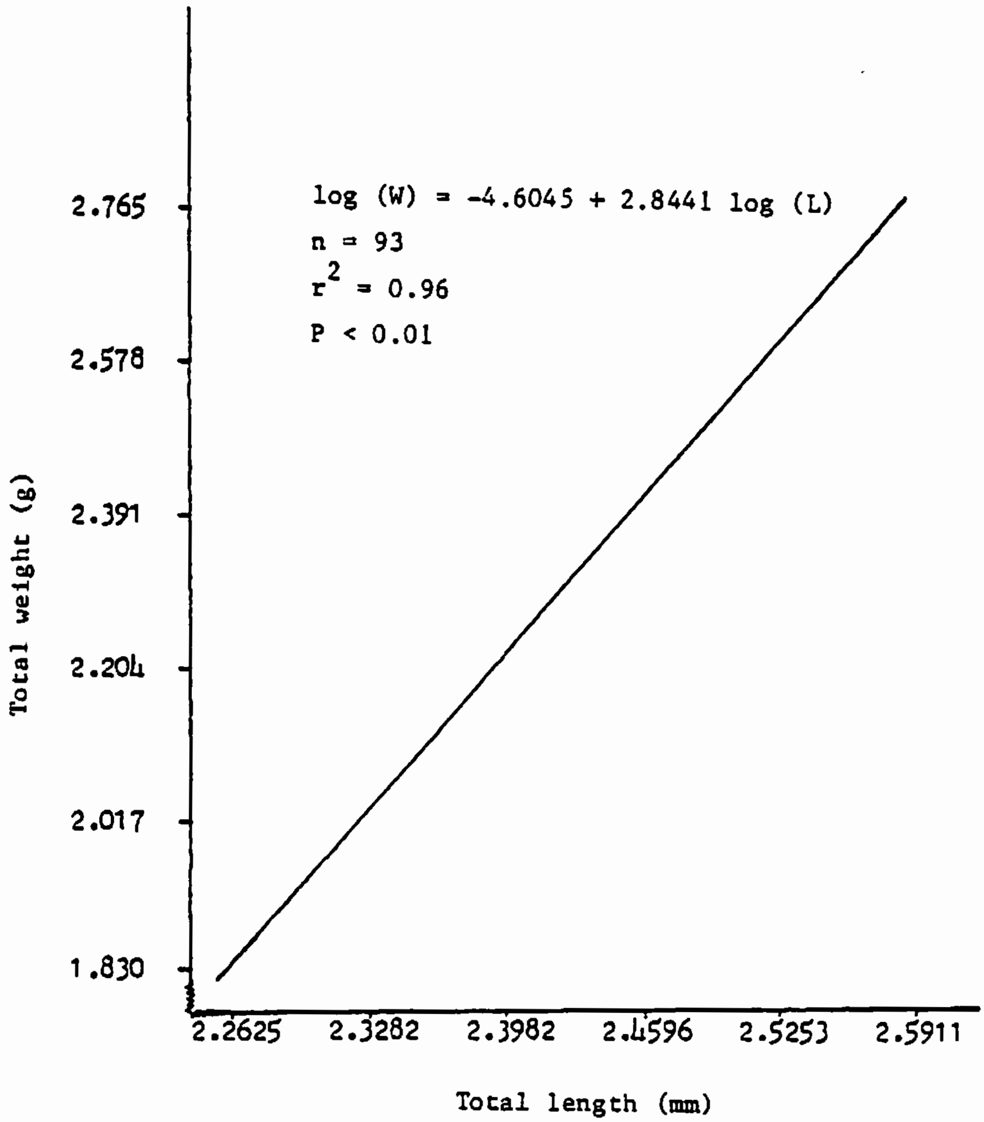

Figure 3. The common logarithm of weight on total length for 93 rainbow trout (Salmo gairdneri) in south-central South Dakota, summer 1977.

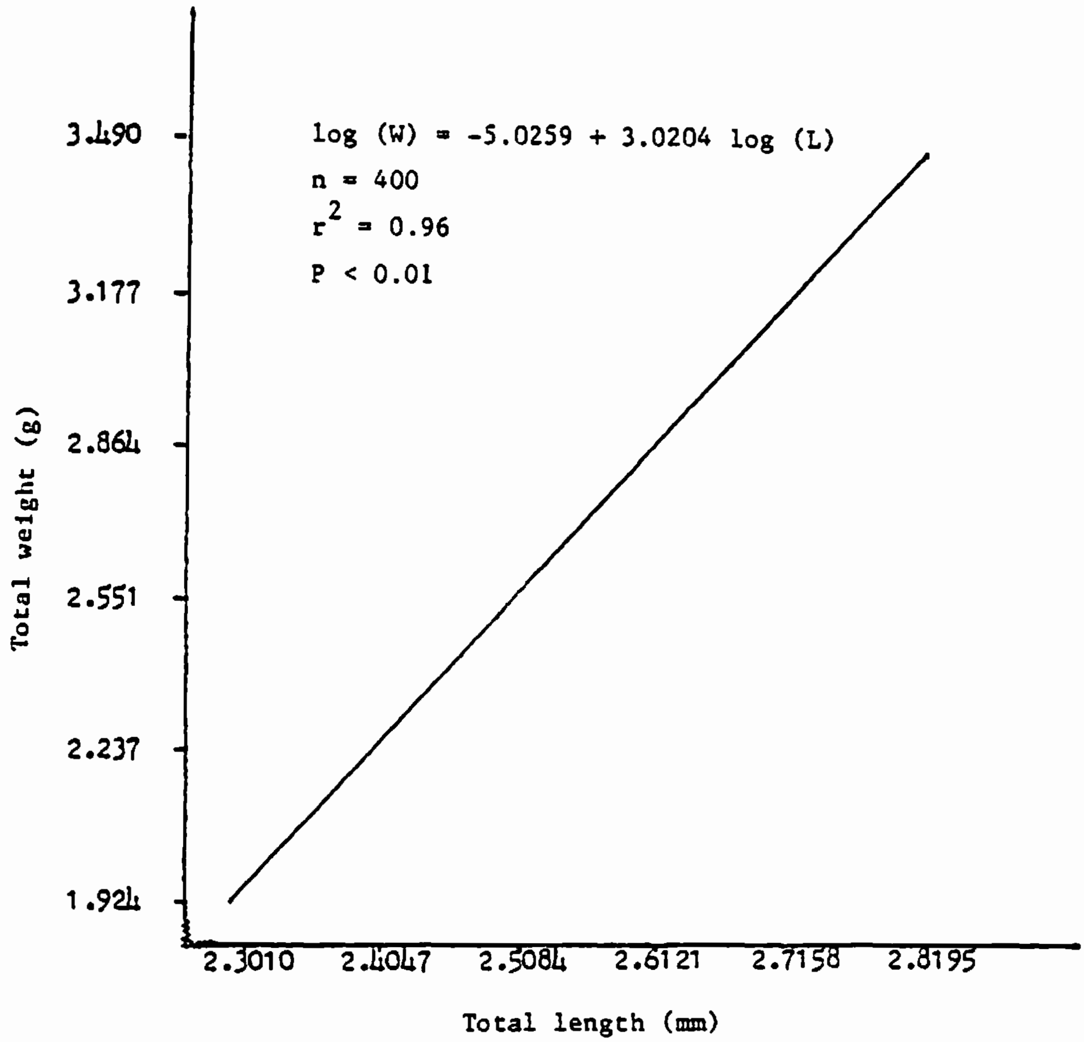

Figure 4. The common logarithm of weight on total length for 400 rainbow trout (Salmo gairdneri) in south-central South Dakota, summer 1978.

The regression coefficient 2.844 in 1977 is close to the 2.764 value Hansen (1952) reported for rainbows in a Wyoming lake and the 2.823 value Varley et al. (1971) reported in Utah. Carlander (1969) stated that the genus Salmo generally have values less than 3.0. Values less than 3.0 demonstrate linear growth taking place at a greater rate than growth in weight and is termed allometric growth. The regression coefficient 3.020 in 1978 represented rainbow trout which were increasing faster in weight than length. The regression coefficient values for both 1977 and 1978 reflected good trout condition.

The average total length of age-group I rainbow trout was 172 and 184 mm for the summers of 1977 and 1978 (Tables 4 and 5). The growth rate of age-group I rainbow trout ranged from a low of 131 mm in the Dykstra pond to a high of 331 mm in the J. Mayer pond. This growth rate is faster than the growth rates of 107 and 120 mm in 2 Ontario ponds (McCrimmon and Berst 1961; Stocek and McCrimmon 1965) and 124 mm in Minnesota (Eddy and Carlander 1939). The growth rate was slower than the 200 mm Carline et al. (1976) reported for a small Wisconsin pond and the 203 mm Eipper (1964) reported for New York ponds.

The average growth rate for age-group II rainbow trout was 225 mm for 1977 and 290 mm for 1978 (Tables 4 and 5). The slower growth rate in 1977 may be partly explained by the fact that 27 of the 35 rainbow trout were collected from Booth pond where the average growth of age-group II rainbow trout was only 224 mm. The average growth rate in 1978 was greater than the average growth rate of 282 mm in New York farm ponds (Eipper 1960) or 231 mm in Minnesota (Eddy and Carlander 1939).

Table 4. Average calculated total lengths and increments of 93 rainbow trout (Salmo gairdneri) in south-central South Dakota, summer 1977.

Year captured	Age-group	Number of fish	Average calculated total length at annulus	
			I	II
1977	I	58	195.3893	
	II	35	148.1418	224.9108
Average lengths			171.7655	224.9108
Average increments			171.7655	76.7691

Table 5. Average calculated total lengths and increments of 400 rainbow trout (*Salmo gairdneri*) in south-central South Dakota, summer 1978.

Year captured	Age group	Number of fish	Average calculated total length at annulus				
			I	II	III	IV	V
1978	I	275	180.3799				
	II	32	195.1706	311.7659			
	III	76	203.5370	305.0005	385.5005		
	V	17	158.4709	252.8719	346.2505	434.1763	498.5872
Average lengths			184.3895	289.8794	365.8755	434.1763	498.5872
Average increments			184.3895	104.1532	86.9393	87.9258	64.4690

The average growth increment for the second year was 77 mm in 1977 and 104 mm in 1978. This growth rate is approximately half the first year growth rate for both 1977 and 1978.

The average growth rate of age-group III rainbow trout was 366 mm (Table 5). This growth rate was faster than the 244 mm reported in a small pond in Ontario (McCrimmon and Berst 1961), 325 mm in Minnesota (Eddy and Carlander 1939), and 343 mm in New York (Eipper and Regier 1962). The average growth increment for the third year of growth was 87 mm, approximately the same as the second year of growth.

The average growth rate for age-group V rainbow trout was 499 mm (Table 5). This is faster than the 318 mm McCrimmon and Berst (1961) reported for an Ontario pond and slower than 521 mm in Minnesota reported by Eddy and Carlander (1939). The average growth increment for the fifth year had decreased to 64 mm which is approximately one-third of the first year growth. Crossman and Larkin (1959), McFee (1966), and Wilkins et al. (1967) reported that at approximately 300 mm forage fish were required by rainbow trout to maintain fast growth. In the National Grassland N. pond, where fathead minnows (*Pimephales promelas*) comprised 76.0% of the volume of food eaten, first and second year growth was 162 mm and 158 mm, respectively.

Body-scale Relationship

The body-scale relationship was not used in calculating growth data in this study. The body-scale relationship for 1978 was calculated to help define this relationship for trout in south-central South Dakota.

To obtain the necessary data to calculate the theoretical growth curve, rainbow trout from the different ponds were pooled in 1978. The regression equation for 1978 was $r^2 = 0.95$; L = -27.3284 6.1330 S (40X) (Fig. 5).

The equation was based on 400 rainbow trout ranging from 200 - 600 mm and represented age-groups I through V. This lack of small fish in the regression is reflected in the rather high intercept. The intercept does not represent the fish at time of scale formation. This strong relationship between body length and scale measurements plus the large sample size and size range gives an accurate estimate of the length of rainbow trout at various ages.

Rainbow Trout Food Analysis

During the summer 1978, 463 stomachs were collected from rainbow trout taken from 29 ponds. Forty-eight (10.4%) of the stomachs were empty. Hemipterans were the dominant food eaten numerically (25.5%), in frequency (64.9%), and volumetrically (29.0%); they had a relative importance index value of 29.4%. Gastropods comprised numerically 17.2% of the diet of the fish and had a relative importance index value of 14.6%. Coleopterans had the second highest relative importance index (14.8%) and a frequency value of 51.3%. Other organisms frequently consumed were Diptera, Odonata, and Cyprinidae (Table 6).

Sunde et al. (1970) reported that hemipterans were one of the dominant food items of rainbow trout in small Canadian lakes while gastropods were the dominant food of rainbow trout in Montana

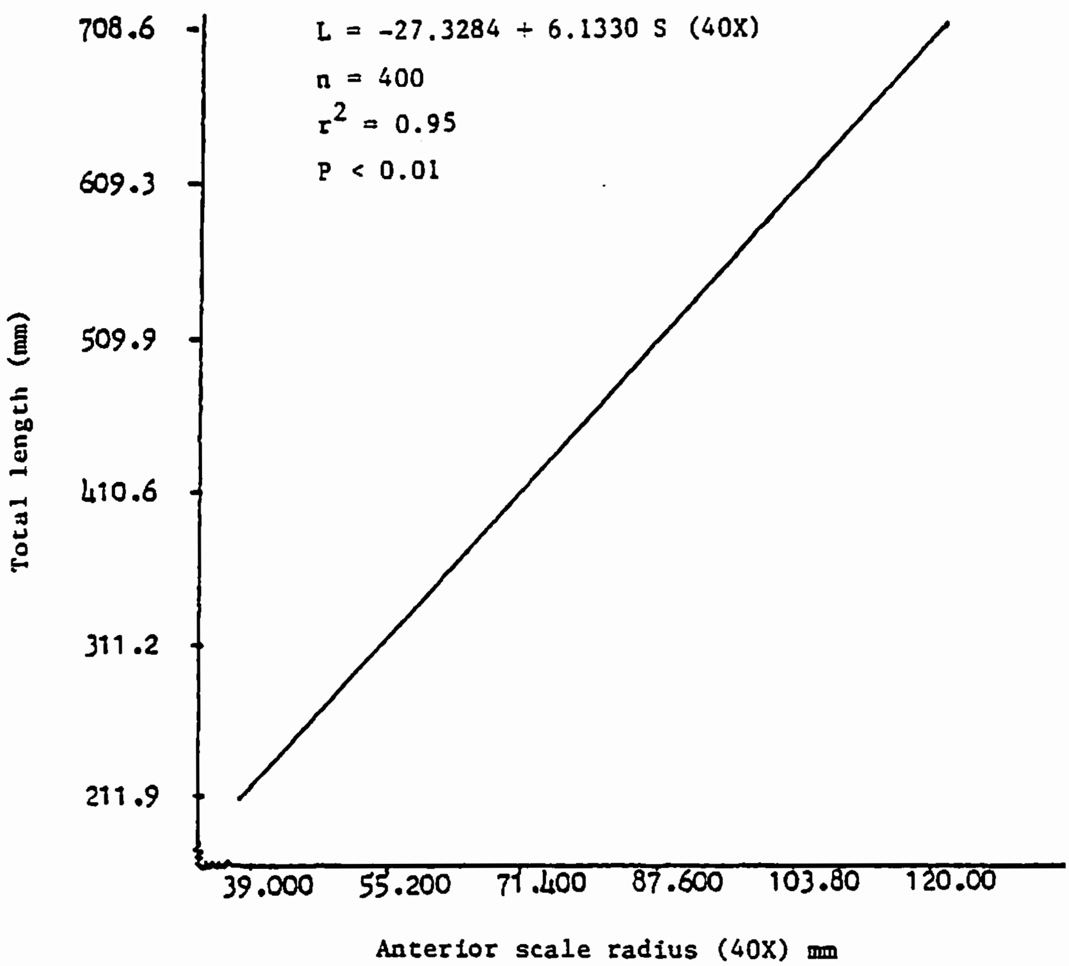

Figure 5. The relationship between body length and anterior scale radius of 400 rainbow trout (*Salmo gairdneri*) for the summer 1978 in south-central South Dakota.

Table 6. Stomach contents of the 463 rainbow trout (*Salmo gairdneri*) collected in 29 ponds in south-central South Dakota, summer 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]
Hemiptera	25.5	64.9	29.0	29.4
Coleoptera	9.3	51.3	9.1	14.8
Odonata				
Anisoptera	3.7	17.8	11.9	7.1
Zygoptera	5.2	21.4	6.4	6.1
Gastropoda	17.2	27.8	21.6	14.6
Diptera	15.4	33.3	5.8	9.2
Ephemeroptera	2.0	21.4	1.5	1.7
Amphipoda	4.3	12.7	0.7	2.9
Cladocera	11.4	9.6	0.2	3.9
Hydracarina	3.0	11.9	0.3	2.9
Tricoptera	0.4	3.8	1.7	1.0
Hirudinea	0.3	1.1	0.8	0.6
Decapoda	Tr[e]	0.1	0.1	0.1
Pelecypoda	0.1	0.3	0.2	0.1
Nematomorpha	0.1	1.2	Tr	0.2
Terrestrial organisms	Tr	1.6	0.2	0.3
Aquatic vegetation	Tr	0.1	0.1	Tr
Cyprinidae	2.4	6.2	10.9	5.2

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

(Kaeding and Kaya 1978), Wisconsin (Carline et al. 1976), and British Columbia (Efford and Tsumura 1973). Gastropods represent an important nutrient source for trout. Swift (1970) reported that only 229 snails were required to produce 1,000 cal while 759 and 677 chironomids and dipterans, respectively, were required to produce the same caloric value.

Cladocerans were numerically the dominant food eaten while hemipterans were the dominant food volumetrically consumed in May 1978 by age-groups II and III rainbow trout (Table 7).

Gastropods were the dominant food eaten numerically (21.9%) and volumetrically (28.6%) by age-group I rainbow trout in June. Hemipterans had the greatest relative importance index (23.7%) and were second volumetrically (21.1%) (Table 8). Gastropods were numerically (25.0%) the dominant food eaten by age-groups II through V rainbow trout in June (Table 9).

Dipterans were numerically (26.2 - 36.0%) the dominant food eaten by age-group I, II, and III rainbows in July. While hemipterans were the dominant food eaten volumetrically and in relative importance of age-groups I through III rainbow trout (Tables 10 and 11).

Hemipterans and coleopterans combined constituted numerically 91.4% and 87.5% in relative importance of age-group I rainbow trout in August (Table 12). Hemipterans were the dominant food numerically and had the highest relative importance index for age-groups II and III rainbow trout in August (Table 13). However, anisopterans and cyprinids combined constituted volumetrically 79.2% of the food eaten by age-group II and III rainbow trout in August.

Table 7. The combined stomach contents of 2 age-group II and 5 age-group III rainbow trout (Salmo gairdneri) collected in 2 ponds in south-central South Dakota in May 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]
Hemiptera	5.2	100.0	35.4	18.0
Coleoptera	7.3	80.0	11.8	22.0
Odonata				
Anisoptera	0.3	10.0	3.2	2.5
Zygoptera	17.5	40.0	18.1	15.0
Gastropoda	26.3	55.0	27.9	22.5
Diptera	0.7	10.0	0.1	2.0
Ephemeroptera	0.4	25.0	1.1	4.0
Amphipoda	1.0	25.0	0.9	4.0
Cladocera	41.5	25.0	1.7	9.5

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

Table 8. The combined stomach contents of 170 age-group I rainbow trout (Salmo gairdneri) collected in 7 ponds in south-central South Dakota in June 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]
Gastropoda	21.9	31.1	28.6	19.4
Diptera	8.5	40.2	1.8	8.9
Hemiptera	19.2	56.0	21.1	23.7
Cladocera	18.7	14.5	0.2	6.9
Hydracarina	1.3	10.2	0.1	2.3
Coleoptera	2.5	20.9	5.0	5.6
Odonata				
Anisoptera	5.4	11.1	7.2	6.3
Zygoptera	7.0	27.8	10.5	8.1
Ephemeroptera	7.0	10.8	4.9	4.0
Tricoptera	0.5	7.0	2.8	1.9
Amphipoda	1.3	11.3	0.2	2.3
Pelecypoda	0.2	0.8	0.6	0.3
Decapoda	Tr[e]	0.4	0.3	0.3
Cyprinidae	5.9	9.5	16.2	9.8
Terrestrial organisms	0.1	1.9	0.2	0.4

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

Table 9. The combined stomach contents of 5 age-group II, 5 age-group III, and 17 age-group V rainbow trout (*Salmo gairdneri*) collected in 4 ponds in south-central South Dakota in June 1978.

Aquatic organisms	N[a]	F[b]	V[c]	RI_a[d]
Hemiptera	23.3	52.3	27.9	29.8
Amphipoda	12.5	8.3	2.4	6.3
Coleoptera	9.5	20.0	7.0	10.3
Odonata				
Anisoptera	2.7	18.2	18.7	7.5
Zygoptera	8.9	20.0	7.0	7.5
Amphipoda	13.9	16.8	1.4	6.0
Diptera	0.3	3.0	Tr[e]	0.5
Cladocera	0.8	1.5	Tr	0.5
Hydracarina	0.2	1.5	Tr	0.3
Tricoptera	1.4	7.4	4.9	2.5
Gastropoda	25.0	25.0	25.0	25.0
Hirudinea	1.9	8.3	5.9	4.3

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

Table 10. The combined stomach contents of 140 age-group I rainbow trout (Salmo gairdneri) collected in 10 ponds in south-central South Dakota in July 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]
Hemiptera	21.6	72.5	32.1	26.4
Gastropoda	20.9	20.2	27.6	14.4
Coleoptera	9.3	58.7	9.1	16.1
Diptera	26.2	30.4	11.3	14.2
Cladocera	10.8	14.2	0.1	5.2
Hydracarina	7.6	24.7	0.7	6.9
Odonata				
Anisoptera	0.3	9.9	3.8	2.9
Zygoptera	1.9	22.7	3.7	5.9
Ephemeroptera	0.5	2.1	0.4	0.6
Amphipoda	0.8	6.8	0.2	1.6
Cyprinidae	0.8	6.3	10.8	3.7
Nematomorpha	0.2	4.7	0.1	1.0
Tricoptera	Tr[e]	1.5	0.4	0.4
Pelecypoda	Tr	0.8	Tr	0.2
Terrestrial organisms	0.1	1.5	0.1	0.4

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

Table 11. The combined stomach contents of 39 age-group II and 5 age-group III rainbow trout (Salmo gairdneri) collected in 3 ponds in south-central South Dakota in July 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]
Hemiptera	24.4	47.3	29.4	26.3
Gastropoda	8.0	15.8	14.2	7.3
Coleoptera	11.6	66.7	14.4	19.3
Diptera	36.0	54.4	24.5	22.3
Cladocera	1.0	1.4	Tr[e]	0.3
Hydracarina	1.6	8.6	0.2	2.0
Odonata				
Anisoptera	0.7	12.2	4.6	3.3
Zygoptera	2.5	18.3	2.4	5.3
Ephemeroptera	8.8	18.3	6.8	6.7
Amphipoda	5.0	18.3	1.0	5.0
Tricoptera	0.2	6.9	2.0	1.3
Terrestrial organisms	0.1	5.6	0.6	1.0

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

Table 12. The combined stomach contents of 7 age-group I rainbow trout (*Salmo gairdneri*) collected in 3 ponds in south-central South Dakota in August 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]
Hemiptera	55.2	75.0	54.8	48.5
Odonata				
Anisoptera	6.5	25.0	9.8	8.0
Coleoptera	36.2	50.0	35.3	39.0
Cladocera	0.7	12.5	Tr[e]	2.5
Diptera	1.5	12.5	0.1	2.5

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

Table 13. The combined stomach contents of 5 age-group II and 64 age-group III rainbow trout (*Salmo gairdneri*) collected in 3 ponds in south-central South Dakota in August 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]
Hemiptera	69.7	65.9	16.2	47.7
Odonata				
Anisoptera	13.7	59.9	51.1	27.7
Coleoptera	9.7	41.6	3.7	13.0
Cladocera	0.1	0.6	Tr[e]	0.3
Gastropoda	0.6	0.6	0.2	0.3
Cyprinidae	6.2	14.5	28.1	10.3
Aquatic vegetation	0.1	0.6	0.7	0.3

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

Rainbow trout were captured in 2 ponds in May 1978. Gastropods and odonates comprised 37.0 and 35.0%, respectively, of the relative importance index and 52.5 and 42.5%, respectively, of the total volume of all food eaten in Burgar pond. Daphnidae comprised 83.0% of the total number of food items eaten and corixids comprised 61.5% of the total volume of the food eaten in L. Smith pond (Appendix 2).

Rainbows were captured in 11 ponds in June 1978. Gastropods were the dominant food eaten in 3 of the 7 ponds containing age-group I rainbow trout. They comprised volumetrically 51.1 - 74.6% and had relative importance index values of 32.0 - 55.0% (Appendix 3). Fathead minnows were the dominant and second most dominant food eaten volumetrically in 2 of the 3 ponds where they were observed.

In July 1978, 184 rainbow trout were captured in 11 ponds. Hemipterans, primarily Notonectidae and Corixidae, were the dominant foods eaten volumetrically by rainbow trout in 3 of the 8 ponds. Gastropods were the dominant food eaten in 2 of the 8 ponds. Dipterans, primarily Chironomidae and Chaoborinae, were the dominant foods eaten numerically and in relative importance in 3 of the 8 ponds containing age-group I rainbow trout. Cyprinids were the dominant food eaten volumetrically in 2 of the 3 ponds where they were observed. Dipterans were the dominant food eaten numerically (60.4 and 32.8%) in the 2 ponds containing age-group II rainbow trout. Hemipterans were the dominant food eaten by age-group III rainbow trout in Wellman pond (Appendix 4).

Seventy-eight rainbow trout were collected in 5 ponds in August 1978. Hemipterans comprised numerically 33.3 - 73.1% and had a relative importance index value of 37.0 - 58.0% (Appendix 5). Aeshnidae comprised volumetrically 58.7 - 84.4% of the food eaten by age-group III rainbow trout.

Hemipterans, gastropods, and dipterans were the dominant food eaten by age-group I and II rainbow trout in the summer 1978. Odonates were the dominant food eaten volumetrically in 5 of the 6 ponds containing age-groups III through V rainbow trout. Anisopterans comprised only 4.2% volumetrically of the food eaten by age-group I rainbow trout in Daum pond but 22.5% of the food eaten by age-group II rainbow trout. Ephemeropterans comprised volumetrically 5.0% of the diet of age-group I rainbow trout, while they comprised 18.4% of the food eaten by age-group III rainbow trout in Wellman pond. These findings agree with Stocek and McCrimmon (1965) and Bisson (1978) who found that as trout become larger they select larger prey. When rainbow trout reach approximately 300 mm, fish become an important item in their diet when available (Crossman 1959; Crossman and Larkin 1959; Stocek and McCrimmon 1965; McFee 1966; Wilkins et al. 1967; and Brynildson and Kempinger 1973). Cyprinids were the dominant food eaten volumetrically in 4 of the 8 ponds where they were observed. The average total length of rainbow trout in 3 of these 4 ponds was greater than 317 mm.

Relative Effectiveness of Stocking Program

A total of 47 different ponds were sampled in the 2 years. Rainbow trout were captured in 31 of these ponds in at least 1 of the 2 years. The trout exhibited growth rates faster than the rates reported for neighboring states and southern Canada. The average coefficient of condition values for 1977 (1.04) and 1978 (1.07) are greater than the value (1.00) reported by Wales (1946) as being satisfactory for rainbow trout.

It appears the effectiveness of the program could be improved by checking ponds for indigenous fish populations prior to stocking trout. Trout survival was poor in ponds that contained largemouth bass, black bullhead (*Ictalurus melas*), or white sucker (*Catostomus commersoni*) populations.

Of the 47 ponds sampled, 25 ponds (53.2%) appeared to have excellent trout populations. If Mellette, Gregory, and Buffalo counties are excluded, 25 of the 33 remaining ponds (75.8%) had excellent rainbow trout populations. Stocking rainbow trout in south-central South Dakota stock ponds appears to be successful expecially in Jones, Lyman, Tripp, and Stanley counties.

Survival

Although percent survival could not be calculated for this study several observations were noted. Six sampled ponds had resident largemouth bass populations; only 6 rainbow trout were captured in these ponds. Rawson (1948) reported poor survival of rainbow trout stocked into lakes already populated with a predator fish. Fraser (1972) reported only 0.5 - 5.0% survival of rainbow trout stocked in lakes containing spiny-rayed fish.

Rainbow trout in South Dakota ponds are normally stocked in 1 or 2 year cycles depending on the availability of fish and the fishing pressure on the pond. Although rainbow trout are stocked at 1 or 2 year cycles, none of the ponds in 1977 contained more than 1 year-class and only 4 ponds in 1978 contained more than 1 year-class. Wales (1946) attributed low survival of subsequent rainbow trout stockings to predation by large rainbow trout. Eipper and Regier (1962) recommended heavy fishing pressure as soon as possible to maximize harvest and minimize predation on subsequent stockings. Wallis (1963) reported that a 2 or 3 year stocking cycle would produce satisfactory results in semi-isolated lakes which receive moderate fishing pressure. It appears that a 3 year stocking cycle in ponds in south-central South Dakota may be as effective and less expensive than the present stocking policy.

Physicochemical Evaluation

Temperature

The maximum surface temperatures recorded were 26.0 C in 1977 and 28.5 C in 1978 (Table 14). Eleven ponds had surface temperatures $\geq$ 26.0 C which is at the upper incipient lethal temperature (25.6 - 26.2 C) reported for rainbow trout (Bidgood and Berst 1969; Cherry et al. 1977; Hokanson et al. 1977; Kaya 1978) (Appendices 6 and 7). However, the maximum bottom temperature recorded for 1977 and 1978 was 23.0 C (Table 14). This is the maximum temperature at which rainbow trout can maintain their weight for 40 days (Hokanson et al. 1977). Eight ponds in 1977 and 30 ponds in 1978 had water temperatures $\leq$ 21.0 C which is near the preferred water temperature of 19.0 - 20.0 C for rainbow trout (McCauley and Pond 1971; Cherry et al. 1975). Rainbow trout were captured in all 3 ponds having surface water temperatures $\geq$ 26.0 C in 1977 and in 5 of the 8 ponds in 1978. The three ponds where rainbow trout were not captured contained water temperatures below their upper incipient lethal temperature.

Table 14. Physical and chemical data for 47 rainbow trout (Salmo gairdneri) ponds in south-central South Dakota during the summers of 1977 and 1978.

	1977	1978
Lake area (hectares)		
Range	0.4 - 32.4	0.4 - 8.1
Mean	3.0	1.5
Maximum depth (m)		
Range	4.0 - 8.0	3.0 - 7.0
Mean	5.0	4.5
Temperature (C) range		
Surface	19.0 - 26.0	19.0 - 28.5
2 m	18.0 - 23.0	16.0 - 26.5
4 m	11.0 - 22.0	11.5 - 24.8
Temperature (C) mean		
Surface	23.4	23.6
2 m	21.9	21.5
4 m	20.1	18.8
Dissolved oxygen (mg/l) range		
Surface	8.0 - 12.0	5.5 - 15.5
2 m	7.0 - 11.0	0.0 - 15.0
4 m	0.0 - 10.5	0.0 - 12.0
Dissolved oxygen (mg/l) mean		
Surface	9.3	8.6
2 m	8.7	7.5
4 m	3.9	4.6
pH		
Range	6.5 - 8.7	7.2 - 11.0
Specific conductance (μmho/cm)		
Range	255 - 1860	130 - 2720
Mean	811	725
Total hardness (mg/l as $CaCO_3$)		
Range	100 - 860	50 - 890
Mean	301	228
Total alkalinity (mg/l as $CaCO_3$)		
Range	60 - 130	15 - 170
Mean	88	81

Dissolved Oxygen

Dissolved oxygen levels in 1977 ranged from 10.0 mg/l at the surface to 0.0 mg/l at the bottom. Dissolved oxygen levels in 1978 ranged from 15.5 mg/l at the surface to 0.0 mg/l at the bottom (Table 14). The ponds in 1977 and 1978 all contained some water with dissolved oxygen levels near the 6.0 mg/l required for good rainbow trout growth (Appendices 6 and 7) (Ohio River Valley Water Sanitation Committee 1956; Davison et al. 1959; Davis 1975). Graham (1966) reported the normal diurnal dissolved oxygen fluctuation for ponds in south-central South Dakota to be approximately 2.0 mg/l.

Although dissolved oxygen levels appeared to be sufficient, this one-time measurement only indicated that the dissolved oxygen levels were above the desired level for that particular day. Dissolved oxygen levels can decline drastically in small eutrophic waters following a phytoplankton bloom collapse or following prolonged periods of cloudy weather (Boyd 1979). Many ponds had heavy phytoplankton blooms. Myers and Peterka (1976) reported that all rainbow trout died in 2 of their 4 prairie ponds in North Dakota following a phytoplankton collapse in August. Ayles et al. (1976) reported that rainbow trout mortalities occurred in 20% of small eutrophic lakes in central Canada following a phytoplankton bloom collapse in early August.

There was water available in all ponds within the temperature and dissolved oxygen levels reported acceptable for rainbow trout. However, many were close to the physiological tolerance level for trout and often only a small layer of pond was suitable. All but 5 ponds were sampled before August when phytoplankton collapses are most common

(Ayles et al. 1976). Also, the resistance of rainbow trout to low dissolved oxygen levels is reduced by increased water temperatures (Gibson and Fry 1954). Marginal dissolved oxygen levels and high water temperatures may have been responsible for the failure of trout to survive in 16 of the study ponds. Three ponds in 1977 and 12 ponds in 1978 had $\leq$ 1.0 mg/l dissolved oxygen below 2.0 m. Fish were not captured in 2 of these ponds in 1977 and 8 of these ponds in 1978.

pH

The pH levels in 1977 ranged from 6.5 - 8.7 (Table 14). These values were within the 6.5 - 9.0 desirable range for fish (Swingle 1969). The pH values in 1978 ranged from 7.2 - 11.0 (Table 14). Four ponds had pH values greater than the level Eicher (1946) reported as causing heavy rainbow trout mortality. Eight ponds had values $\geq$ 9.5 which Jordan and Lloyd (1964) reported as causing 50% rainbow trout mortality when the fish were continuously exposed for 15 days (Appendices 8 and 9).

This was a one-time measurement and many ponds contained phytoplankton blooms which could cause high pH values during periods of intense photosynthesis. Some ponds may not have reached their upper pH value. The pH in small eutrophic waters normally increases as the summer season progresses (King 1970). However, of the 8 ponds with pH values $\geq$ 9.5, 5 had excellent trout populations. In the 3 ponds where rainbow trout were not captured, one had a low water level in 1977 and in another the trout were in poor condition at the time of stocking. Tripp County ponds in 1978 had the highest average pH value (9.7) and all 5 ponds had excellent trout populations. Therefore, high pH values were not believed to have been deleterious to rainbow trout survival. High pH values could be a problem at stocking. Witschi and Ziebell (1979) reported that pH shock killed 68% of the rainbow trout fingerlings when the trout from hatchery waters of 7.2 pH were stocked in ponds with a pH value of 9.5.

Conductivity

Conductivity levels in 1977 ranged from 249 - 1,907 µmho/cm with an average 881 µmho/cm. The levels in 1978 ranged from 150 - 2,856 µmho/cm with an average 660 µmho/cm.

Barica (1975) reported that trout summer fish kills in prairie ponds resulted from heavy algal bloom collapses in ponds with conductivity levels between 800 - 2,000 µmho/cm and where chlorophylll _a_ concentrations exceeded 100 µg/l. He labeled these southern Manitoba ponds as "high summerkill risks".

Eight ponds in 1977 and 15 ponds in 1978 were within the 800 - 2,000 µmho/cm range (Appendices 8 and 9). Rainbow trout were captured in 7 of the 8 ponds in 1977. The one pond where rainbow trout were not captured contained a resident largemouth bass population. Rainbow trout were captured in 12 of these 15 ponds in 1978. Failure to capture rainbow trout in 2 of the 3 remaining ponds could be explained by the fact that one contained a resident largemouth bass population and the other pond had a low water level. Conductivity did not appear to be a good parameter to predict summerkills in south-central South Dakota ponds. Chlorophyll _a_ concentration may be a good indicator but were not measured in this study. Barica (1975) reported that in the summer, non-summerkill lakes showed relatively uniform chlorophyll _a_ levels while summerkill lakes oscillated with chlorophyll _a_ exponentially increasing to over

100 μg/l within a 1 to 2 week period. This was followed within a few weeks by a sudden collapse of the algal populations.

Total Hardness and Total Alkalinity

Total hardness levels in 1977 ranged from 100 - 860 mg/l with an average of 301 mg/l. The levels in 1978 ranged from 50 - 890 mg/l and averaged 228 mg/l (Table 12). These waters would be classified as moderately hard to very hard (Sawyer and McCarty 1967). Total alkalinity levels in 1977 ranged from 60 - 130 mg/l with an average of 88 mg/l. The levels in 1978 ranged from 15-170 mg/l with an average of 81 mg/l.

The total hardness and total alkalinity levels in all ponds except one were above the 20 mg/l (Boyd 1974) considered necessary for excellent fish production. Rainbow trout were not captured in the pond where total alkalinity was less than 20 mg/l. All ponds in 1977 contained at least 60 mg/l total alkalinity. Eight ponds in 1978 contained $\leq$ 30 mg/l total alkalinity and had a mean average pH value of 10.0; compared to an average pH of 8.6 excluding these ponds. Rainbow trout were captured in 4 of these 8 ponds. High pH values during May stockings may have been a problem in ponds where total alkalinity levels were not sufficient to buffer against drastic diel pH changes.

CONCLUSION

Rainbow trout in south-central South Dakota exhibited excellent growth and condition. Of the 47 ponds sampled, 25 (53.2%) appeared to have excellent trout populations. The poor survival in Mellette, Gregory, and Buffalo counties may call for a re-evaluation if survival of subsequent stockings is poor. A future study monitoring chlorophyll *a* concentrations may identify these ponds as "high summerkill risks."

Rainbow trout are presently being stocked in a 1 or 2 year stocking cycle. A survival study comparing this policy with a 3 year stocking cycle may reveal a 3-year cycle to be as effective and less expensive.

McFee (1966) and Wilkins et al. (1967) reported that at approximately 300 mm, forage fish were required by rainbow trout to maintain fast growth. A study comparing the growth rates and survival of all size-classes of rainbow trout stocked with and without minnows would help determine if a minnow stocking policy would be beneficial in south-central South Dakota.

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A P P E N D I X

Appendix 1. Mailing address of owners of rainbow trout (Salmo gairdneri) stock ponds examined in south-central South Dakota during 1977 and 1978.

Pond owner	Address
Arvid Ambur	Presho, SD 57568
Bryan Baughman	RFD 3, Whitelake, SD 57383
Larry Booth	Vivian, SD 57576
David Brost*	Murdo, SD 57559
Herman Brost*	Murdo, SD 57559
Grant Burgar	Presho, SD 57568
Lee Calhoun	Winner, SD 57580
Charles Chamberlain	White River, SD 57579
Johnny Daum	Okaton, SD 57562
Jim Deutsch	Belvidere, SD 57521
Ben Dykstra	Murdo, SD 57559
Ed Eckerman	RR #1 Winner, SD 57580
Oakley Eide	Burke, SD 57523
Jack Frantz**	Ideal, SD 57541
Richard Fronek	Wood, SD 57585
Derrill Glynn	Belvidere, SD 57521
Robert Iverson	Murdo, SD 57559
Densel Kinsley	Murdo, SD 57559
Neil Lantz	Ideal, SD 57541
Glenn Mayer	Pukwana, SD 57370
John Mayer**	Pukwana, SD 57370
National Grassland**	Federal Building, Pierre, SD 57501
Bob Olson	Midland, SD 57552
Alf Osnes	Burke, SD 57523
Harry Perry	Presho, SD 57568
Ronald Peterson	Pukwana, SD 57370
Raymond Pistulka**	Bonesteel, SD 57317
Odeen Rassmussen	Belvidere, SD 57521
Richard Reur	Reliance, SD 57569
Lloyd Rust	Murdo, SD 57559

Appendix 1. (Continued)

Pond owner	Address
Kenneth Sargent	Clearfield, SD 57581
Vernon Sivage	Ft. Pierre, SD 57532
Charles Smikle	Herrick, SD 57538
Dick Smith**	Vivian, SD 57576
Lyle Smith	Presho, SD 57562
Noel Wellman	Okaton, SD 57562
Don Wilinski	Presho, SD 57568
Robert Wilson	Murdo, SD 57559

*Three ponds

**Two ponds

Appendix 2. Stomach contents of rainbow trout (Salmo gairdneri) collected in two ponds in south-central South Dakota May 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]	N	F	V	RI_a
	Burgar pond Age-group III				L. Smith pond Age-group II			
Odonata								
Anisoptera								
Aeshnidae	0.6	20.0	6.4	5.0				
Zygoptera								
Coenagriidae	35.0	80.0	36.1	30.0				
Gastropoda								
Physidae	16.3	40.0	26.9	17.0				
Lymnaeidae	35.6	40.0	25.6	20.0	0.7	50.0	3.3	8.0
Hemiptera								
Notonectidae	0.6	20.0	1.1	4.0	0.7	50.0	8.2	8.0
Corixidae					9.2	100.0	61.5	24.0
Coleoptera								
Gyrinidae	0.6	20.0	0.9	4.0				
Haliplidae	8.1	40.0	1.1	10.0	1.3	50.0	1.2	8.0
Dytiscidae	1.9	20.0	1.9	5.0	2.6	100.0	18.5	17.0
Diptera								
Chironomidae	1.3	20.0	0.2	4.0				
Ephemeroptera								
Caenidae					0.7	50.0	2.2	8.0
Amphipoda								
Gammaridae					2.0	50.0	1.7	8.0
Cladocera								
Daphnidae					83.0	50.0	3.4	19.0
Number of stomachs			5				2	
Number of empty stomachs			0				0	

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

Appendix 3. Stomach contents of rainbow trout (Salmo gairdneri) collected in 11 ponds in south-central South Dakota June 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]	N	F	V	RI_a
	Perry pond Age-group I				Lantz pond Age-group I			
Gastropoda								
Physidae	32.2	48.8	74.6	42.0				
Diptera								
Chironomidae	9.8	25.6	1.8	10.0				
Hemiptera								
Corixidae	9.5	41.9	12.8	17.0	11.8	17.6	0.5	10.0
Cladocera								
Daphnidae	46.1	25.6	0.4	20.0				
Hydracarina	1.2	4.7	0.1	2.0				
Coleoptera								
Haliplidae	0.1	4.7	Tr[e]	1.0				
Helodidae	Tr	2.3	0.1	1.0				
Chrysomelidae					2.9	5.9	0.1	3.0
Odonata								
Aeshnidae	Tr	2.3	0.6	1.0	35.3	23.5	23.5	27.0
Coenagriidae	Tr	2.3	0.1	1.0	8.8	5.9	0.4	5.0
Ephemeroptera								
Caenidae	Tr	2.3	Tr	1.0				
Tricoptera								
Leptoceridae	0.8	2.3	5.0	2.0				
Cyprinidae	0.1	4.7	4.5	2.0	41.2	47.1	75.5	55.0
Number of stomachs		43				17		
Number of empty stomachs		2				5		

Aquatic organism	N	F	V	RI_a	N	F	V	RI_a
	Ambur pond Age-group II				Booth pond Age-group III			
Hemiptera								
Corixidae	38.5	66.7	56.6	44.0	17.2	20.0	9.9	10.0
Notonectidae	3.8	33.3	10.6	13.0	24.1	60.0	25.9	24.0
Coleoptera								
Elmidae					6.9	20.0	3.6	7.0
Hydrophilidae					6.9	40.0	6.0	12.0
Gyrinidae					13.8	20.0	12.0	10.0
Dytiscidae					10.3	40.0	6.2	12.0
Odonata								
Aeshnidae					6.9	20.0	29.8	12.0
Lestidae					10.3	20.0	6.3	8.0
Amphipoda								
Gammaridae	50.0	33.3	9.4	25.0	3.5	20.0	0.3	5.0
Hirudinea	7.7	33.3	23.4	17.0				
Number of stomachs		3				5		
Number of empty stomachs		1				0		

Appendix 3. (Continued)

Aquatic organisms	N[a]	F[b]	V[c]	RI_a[d]	N	F	V	RI_a
	Eckerman pond Age-group I				Kinsley pond Age-group I			
Gastropoda								
Physidae					33.1	60.0	63.2	27.0
Lymnaeidae	1.9	16.7	2.0	3.0	5.2	10.0	4.4	4.0
Planorbidae	0.3	5.6	3.0	1.0	0.2	3.3	0.2	1.0
Pelecypoda								
Unionidae	1.6	5.6	4.0	2.0				
Diptera								
Chironomidae	20.0	50.0	3.8	12.0	8.0	63.3	1.2	13.0
Culicidae	5.1	50.0	1.8	9.0	2.9	12.3	0.8	3.0
Hemiptera								
Corixidae	2.2	33.3	3.1	6.0	2.8	36.7	3.1	8.0
Notonectidae	16.6	77.8	43.0	22.0	0.1	3.3	Tr	1.0
Cladocera								
Daphnidae	0.2	5.6	Tr	1.0	28.6	10.0	0.2	7.0
Hydracarina	0.8	16.7	0.1	3.0	0.4	10.0	Tr	2.0
Coleoptera								
Dytiscidae					0.7	16.7	0.8	3.0
Odonata								
Aeshnidae	1.2	40.3	5.5	8.0				
Coenagriidae	1.2	16.7	1.8	3.0	8.4	50.0	10.2	12.0
Lestidae	0.3	16.7	0.4	3.0				
Ephemeroptera								
Caenidae	48.1	66.7	34.1	24.0	0.5	3.3	0.3	1.0
Amphipoda								
Gammaridae	0.7	22.2	0.1	4.0	6.5	43.3	0.9	9.0
Hirudinea					2.7	46.7	14.7	11.0
Number of stomachs		18				30		
Number of empty stomachs		0				0		

	G. Mayer pond Age-group I				Frantz W. pond Age-group I			
Gastropoda								
Physidae					76.1	66.7	48.3	49.0
Planorbidae					2.9	13.3	0.8	4.0
Decapoda								
Cambarinae					0.3	3.3	2.0	2.0
Diptera								
Chironomidae					5.3	10.0	0.3	4.0
Culicidae	57.1	100.0	24.9	28.0				
Hemiptera								
Corixidae	2.4	50.0	4.1	9.0	3.2	26.7	1.2	8.0
Notonectidae	16.7	100.0	27.0	30.0				
Hydracarina					2.9	10.0	0.1	3.0

Appendix 3. (Continued)

Aquatic organisms	N[a]	F[b]	V[c]	RI$_a$[d]	N	F	V	RI$_a$
Coleoptera								
Elmidae					0.3	3.3	0.2	1.0
Haliplidae					1.3	6.7	0.1	2.0
Dytiscidae	1.2	50.0	2.2	8.0				
Chrysomelidae					0.3	3.3	0.2	1.0
Odonata								
Aeshnidae					1.1	13.3	4.3	5.0
Lestidae	22.6	100.0	41.8	25.0	0.5	3.3	0.2	1.0
Ephemeroptera								
Caenidae					0.3	3.3	Tr	2.0
Amphipoda								
Gammaridae					0.3	3.3	Tr	1.0
Cyprinidae					2.9	20.0	42.3	17.0
Number of stomachs			2			30		
Number of empty stomachs			0			2		

	Calhoun pond Age-group I				Olson pond Age-group V			
Gastropoda								
Physidae	0.8	10.0	3.3	2.0				
Planorbidae	0.4	6.7	1.3	1.0				
Diptera								
Chironomidae	5.4	36.7	1.7	7.0	1.1	11.8	0.1	2.0
Culicidae	2.2	20.0	1.3	4.0				
Hemiptera								
Corixidae	11.0	90.0	25.7	22.0	4.5	76.5	3.5	15.0
Notonectidae	0.8	10.3	1.1	3.0	3.8	53.0	4.8	11.0
Gerridae	0.2	3.3	1.0	1.0				
Cladocera								
Daphnidae	55.7	60.0	0.8	20.0	3.2	5.9	Tr	2.0
Hydracarina	3.7	30.0	0.6	6.0	0.6	5.9	Tr	1.0
Coleoptera								
Haliplidae	0.3	10.0	1.2	2.0				
Helodidae	0.1	3.3	Tr	1.0				
Dytiscidae	10.3	56.7	25.5	16.0				
Odonata								
Aeshnidae	0.5	6.7	16.2	4.0	4.0	52.9	45.1	18.0
Coenagriidae	7.1	16.7	18.3	7.0	22.9	52.9	19.8	17.5
Lestidae					2.2	23.5	1.8	5.0
Amphipoda								
Gammaridae	1.1	10.0	0.3	2.0	52.0	47.1	5.2	19.0
Tricoptera								
Leptoceridae					5.7	29.4	19.7	10.0

Appendix 3. (Continued)

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]	N	F	V	RI_a
Coleoptera								
Cantharidae	0.5	13.3	1.6	3.0				
Number of stomachs		30				17		
Number of empty stomachs		0				0		
	Frantz E. pond Age-group II							
Gastropoda								
Planorbidae	100.0	100.0	100.0	100.0				
Number of stomachs		2						
Number of empty stomachs		0						

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

Appendix 4. Stomach contents of rainbow trout (Salmo gairdneri) collected in 11 ponds in south-central South Dakota July 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]	N	F	V	RI_a
	Rust pond Age-group I				Daum pond I and II			
Gastropoda								
Physidae	13.2	29.4	62.0	17.0	41.9	26.7	60.7	30.0
Diptera								
Chironomidae	4.8	35.3	1.8	7.0	31.9	46.7	3.7	19.0
Culicidae	15.3	17.6	10.5	7.0				
Hemiptera								
Corixidae	2.9	58.8	7.9	11.0	12.2	33.3	10.3	13.0
Notonectidae	1.1	41.2	4.1	7.0	2.0	6.7	3.2	3.0
Cladocera								
Daphnidae	50.1	29.4	0.8	13.0				
Hydracarina	8.7	29.4	1.7	6.0	0.4	6.7	Tr[e]	2.0
Coleoptera								
Dystiscidae	2.2	70.6	6.4	13.0	1.3	13.3	1.1	4.0
Haliplidae	0.6	47.1	0.2	8.0	2.4	23.3	0.3	6.0
Hydrophilidae	0.1	5.9	0.2	1.0	2.1	16.7	2.8	5.0
Odonata								
Aeshnidae	0.1	11.8	2.4	2.0	1.3	16.7	8.2	6.0
Coenagriidae	0.2	17.6	0.7	3.0	3.3	23.3	3.0	7.0
Lestidae	0.4	17.6	1.1	3.0				
Ephemeroptera					0.7	3.3	0.3	1.0
Amphipoda								
Gammaridae	0.3	17.6	0.1	3.0	0.1	33.0	Tr	1.0
Cyprinidae					0.1	3.3	4.7	2.0
Terrestrial organisms					0.1	3.3	1.7	1.0
Number of stomachs	17				30			
Number of empty stomachs	0				5			
	D. Brost S.E. pond Age-group I				Wilson pond Age-group I			
Pelecypoda								
Sphaeriidae	0.1	6.7	0.4	1.0				
Diptera								
Chironomidae	19.3	73.3	5.1	14.0	2.4	20.0	0.4	5.0
Culicidae	44.2	33.4	33.7	16.0				
Hemiptera								
Corixidae	7.8	80.0	15.1	15.0	13.4	60.0	17.0	18.0
Notonectidae	10.9	20.0	8.7	6.0	24.4	66.6	53.3	28.0
Cladocera								
Daphnidae	1.6	13.3	Tr	2.0				
Hydracarina	0.7	20.0	0.1	3.0	22.0	13.3	2.0	7.0

Appendix 4. (Continued)

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]	N	F	V	RI_a
Coleoptera								
Dytiscidae	6.9	80.0	14.0	14.0	17.1	53.4	6.5	16.0
Haliplidae	1.1	40.0	0.3	6.0	9.8	40.0	1.7	10.0
Hydrophilidae	0.3	20.0	0.9	3.0	6.7	26.7	12.9	9.0
Gyrinidae					1.2	6.7	2.0	2.0
Odonata								
Aeshnidae	0.9	40.0	13.5	8.0				
Coenagriidae	2.7	33.3	5.6	6.0	3.0	20.0	4.2	5.0
Lestidae	0.1	6.7	0.2	1.0				
Ephemeroptera								
Caenidae	2.1	6.7	2.0	2.0				
Amphipoda								
Gammaridae	1.2	26.7	0.3	4.0				
Number of stomachs		15				15		
Number of empty stomachs		0				0		

	D. Brost N.E. pond Age-group I				D. Brost N.W. pond Age-group I			
Gastropoda								
Physidae					4.9	12.3	15.9	10.0
Lymnaeidae	2.0	5.9	2.9	2.0	0.3	4.2	0.5	1.0
Diptera								
Chironomidae	2.9	47.1	0.7	9.0	73.0	12.3	19.0	30.0
Culicidae	21.8	11.8	10.3	7.0	9.4	12.4	6.0	8.0
Hemiptera								
Corixidae	16.4	82.4	30.9	22.0	6.1	24.7	11.7	12.0
Notonectidae	28.0	82.3	36.8	25.0	1.9	16.7	6.7	7.0
Cladocera								
Daphnidae	21.6	23.5	0.3	8.0	0.7	8.2	Tr	3.0
Hydracarina	1.5	5.9	0.2	1.0	2.3	20.9	0.9	6.0
Coleoptera								
Dysicidae	1.6	47.1	3.2	9.0	0.1	4.2	0.2	1.0
Haliplidae	0.3	11.8	0.1	2.0				
Gyrinidae	0.2	17.6	0.1	3.0				
Odonata								
Aeshnidae	0.3	5.9	4.6	2.0	0.1	4.2	3.0	2.0
Coenagriidae	2.8	23.5	5.8	5.0	0.4	8.2	1.5	3.0
Ephemeroptera								
Caenidae	0.1	5.9	0.1	1.0	0.1	4.2	0.1	1.0
Amphipoda								
Gammaridae					0.2	4.2	0.1	1.0
Cyprinidae					0.5	12.3	34.5	14.0
Trichoptera	0.4	11.8	4.1	3.0				
Terrestrial organisms	0.1	5.9	0.1	1.0				
Number of stomachs		17				24		
Number of empty stomachs		0				5		

Appendix 4. (Continued)

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]	N	F	V	RI_a
	Iverson pond Age-group I				Wellman pond Age-groups I and III			
Gastropoda								
Physidae	0.7	22.0	3.0	3.0	14.2	11.1	34.4	9.0
Lymnaeidae	17.8	33.0	34.4	11.0				
Planorbidae	0.3	11.0	0.6	2.0	8.4	5.6	2.3	2.0
Diptera								
Chironomidae	6.2	56.0	2.1	9.0	8.5	55.6	1.7	10.0
Culicadae	25.2	33.0	19.7	10.0				
Tabanidae	Tr	6.0	0.2	1.0				
Hemiptera								
Corixidae	3.0	72.0	7.6	11.0	11.0	88.9	15.6	17.0
Notonectidae	2.7	84.0	10.3	13.0	1.4	44.4	3.8	7.0
Cladocera								
Daphnidae	34.1	39.0	0.5	10.0				
Hydracarina	2.5	33.0	0.5	5.0	17.8	33.3	1.8	8.0
Coleoptera								
Dytiscidae	0.6	33.0	1.6	5.0	18.0	66.7	26.8	17.0
Haliplidae	1.9	39.0	0.7	6.0	3.9	27.8	0.7	5.0
Hydrophilidae					1.5	33.5	3.3	6.0
Odonata								
Aeshnidae	0.3	17.0	6.3	3.0				
Coenagriidae	4.3	56.0	11.9	10.0	3.1	16.7	4.8	4.0
Ephemeroptera								
Caenidae					4.8	33.3	3.5	6.0
Amphipoda								
Gammaridae					7.2	50.0	1.3	9.0
Talitridae					0.2	5.6	Tr	1.0
Nematomorpha	Tr	6.0	0.2	1.0				
Terrestrial organisms	Tr	6.0	0.2	1.0				
Number of stomachs		18				18		
Number of empty stomachs		0				0		

	Chamberlain pond Age-group I			
Hemiptera				
Notonectidae	83.3	100.0	99.2	81.0
Hydracarina	16.7	50.0	0.8	19.0
Number of stomachs		2		
Number of empty stomachs		1		

Appendix 4. (Continued)

Aquatic organism	N[a]	F[b]	V[c]	RI_a[d]	N	F	V	RI_a
	Dykstra pond Age-group I				H. Brost pond Age-group II			
Gastropoda								
Physidae	80.9	50.0	29.2	38.0	8.0	20.8	23.7	8.0
Diptera								
Chironomidae					59.2	83.3	14.0	23.0
Culicidae					1.2	8.3	0.5	2.0
Hemiptera								
Corixidae					7.3	66.7	23.6	15.0
Notonectidae					0.2	4.2	0.2	1.0
Belostomatidae					Tr	4.2	0.8	1.0
Cladocera								
Daphnidae					2.9	4.2	Tr	1.0
Hydracarina	1.5	25.0	Tr	6.0	3.7	12.5	0.5	3.0
Coleoptera								
Dytiscidae	1.5	25.0	0.3	6.0	6.8	62.5	12.3	13.0
Haloplidae	7.4	50.0	0.2	14.0	1.4	37.5	0.3	6.0
Gyrinidae					Tr	1.2	0.1	1.0
Odonata								
Aeshnidae					0.2	16.7	3.7	3.0
Coenagriidae					0.5	8.3	1.0	2.0
Ephemeroptera								
Caenidae					1.7	8.3	1.5	2.0
Amphipoda								
Gammaridae					0.1	8.3	Tr	1.0
Nematomorpha	1.5	25.0	0.6	6.0				
Cyprinidae	7.4	50.0	69.6	30.0				
Trichoptera								
Leptoceridae					0.7	20.8	6.1	4.0
Terrestrial organisms					0.9	33.3	6.4	1.0
Number of stomachs			4				24	
Number of empty stomachs			0				1	

[a]% of total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

Appendix 5. Stomach contents of rainbow trout (Salmo gairdneri) collected in 5 ponds in south-central South Dakota August 1978.

Aquatic organism	N[a]	F[b]	V[c]	RI$_a$[d]	N	F	V	RI$_a$
	D. Smith S. pond Age-group I				National Grasslands S. Pond Age-group I			
Hemiptera								
Corixidae	33.3	50.0	32.2	39.0	11.4	50.0	6.6	13.0
Notonectidae					65.7	100.0	70.8	45.0
Odonata								
Aeshnidae					12.9	50.0	19.6	16.0
Coleoptera								
Dytiscidae	66.7	50.0	67.8	62.0	4.3	50.0	2.6	11.0
Haliplidae					1.4	25.0	Tr[e]	5.0
Diptera								
Chironomidae					2.9	25.0	0.2	5.0
Number of stomachs			2				4	
Number of empty stomachs			1				0	
	Reur pond Age-group III				National Grasslands N. Pond Age-group II			
Hemiptera								
Corixidae	34.7	67.0	7.3	21.0	18.0	80.0	2.3	20.0
Notonectidae	12.6	67.0	4.9	16.0	54.1	80.0	11.2	29.0
Odonata								
Aeshnidae	26.8	100.0	84.4	40.0	6.6	60.0	10.2	15.0
Coleoptera								
Dytiscidae	9.3	67.0	2.0	15.0	1.6	20.0	0.2	4.0
Haliplidae					1.6	20.0	Tr	4.0
Cyprinidae					18.0	40.0	76.0	27.0
Number of stomachs			9					5
Number of empty stomachs			0					0

Appendix 5. (Continued)

Aquatic organisms	N[a]	F[b]	V[c]	RI_a[d]	N	F	V	RI_a
	Sivage pond Age-groups I and III							
Hemiptera								
Corixidae	9.5	26.8	1.9	12.0				
Notonectidae	63.6	32.2	19.6	37.0				
Odonata								
Aeshnidae	7.6	19.7	58.7	28.0				
Coleoptera								
Dytiscidae	15.6	17.9	8.7	14.0				
Haliplidae	1.0	3.6	0.1	2.0				
Cladocera								
Daphnidae	0.2	1.8	Tr	1.0				
Gastropoda								
Lymnaeidae	1.7	1.8	0.7	1.0				
Cyprinidae	0.5	3.6	8.2	4.0				
Aquatic vegetation								
Potomogeton	0.2	1.8	2.2	1.0				
Number of stomachs		56						
Number of empty stomachs		25						

[a]% of the total number

[b]% frequency of occurrence

[c]% of the total volume

[d]Relative importance index

[e]Trace, less than 0.05 (ml or %)

Appendix 6. Depth (m), temperature (C), and dissolved oxygen (mg/l) in 18 stock ponds in south-central South Dakota during summer 1977.

Pond	Depth (m)	Temperature (C)	Dissolved oxygen (mg/l)	Date of collection
Baughman	S[a]	26.0	9.0	7-27-77
	2.0	23.0	8.0	
	4.0	11.0	2.0	
	6.0[b]	8.0	0.0	
Booth	S	26.0	10.0	7-28-77
	2.0	23.0	8.0	
	4.0	22.0	4.0	
H. Brost E.	S	23.0	10.0	8-6-77
	2.0	22.0	9.0	
	4.0	21.0	0.0	
H. Brost N.	S	26.0	12.0	8-5-77
	2.5	22.0	11.0	
	4.5	21.0	1.0	
H. Brost W.	S	23.0	10.0	8-4-77
	2.0	22.0	9.0	
	4.0	21.0	1.0	
Burgar	S	25.0	10.0	8-9-77
	2.0	23.0	10.0	
	4.0	22.0	10.0	
	5.0	21.0	2.0	
Daum	S	10.0	10.5	10-8-77
	2.0	10.0	10.5	
	4.0	10.0	10.5	
	5.0	10.0	10.5	
Dykstra	S	10.0	10.0	10-9-77
	2.0	10.0	10.0	
	4.0	9.0	10.0	
Frantz	S	21.0	8.0	8-12-77
	2.0	21.0	7.0	
	4.0	21.0	3.0	
	5.0	21.0	-[c]	

Appendix 6. (Continued)

Pond	Depth (m)	Temperature (C)	Dissolved oxygen (mg/l)	Date of collection
Kinsley	S	9.5	10.0	10-11-77
	2.0	9.0	10.0	
	4.0	9.0	10.0	
	5.0	9.0	10.0	
National Grassland N.	S	24.0	8.0	7-21-77
	2.0	23.0	8.0	
	4.0	22.0	5.0	
	6.0	22.0	0.0	
National Grassland S.	S	24.0	8.0	7-20-77
	2.0	22.0	7.0	
	4.0	22.0	6.0	
	5.0	22.0	0.0	
Reur	S	23.0	9.0	8-11-77
	2.0	22.0	9.0	
	4.0	19.0	6.0	
	5.0	18.0	6.0	
Sargent	S	23.0	10.0	7-31-77
	2.0	22.0	8.0	
	4.0	22.0	3.0	
	6.0	22.0	0.0	
	8.0	21.0	0.0	
D. Smith N.	S	21.0	8.0	7-30-77
	2.0	21.0	8.0	
	5.0	21.0	2.0	
D. Smith S.	S	23.0	9.0	7-29-77
	2.0	21.0	9.0	
	4.5	19.0	0.5	
L. Smith	S	19.0	8.0	7-19-77
	2.0	18.0	9.0	
	4.0	16.0	-	
	6.0	15.0	3.5	

Appendix 6. (Continued)

Pond	Depth (m)	Temperature (C)	Dissolved oxygen (mg/l)	Date of collection
Wilinski	S	24.0	10.0	8-10-77
	2.0	23.0	10.0	
	4.0	22.0	9.0	

[a]Surface

[b]Bottom

[c]Data not available

Appendix 7. Depth (m), temperature (C), and dissolved oxygen (mg/l) in 45 stock ponds in south-central South Dakota during summer 1978.

Pond	Depth (m)	Temperature (C)	Dissolved oxygen (mg/l)	Date of collection
Ambur	S[a]	24.0	7.0	6-28-78
	2.0	24.0	7.0	
	4.0[b]	22.0	7.0	
Baughman	S	19.0	7.0	5-18-78
	2.0	16.0	7.0	
	4.0	11.5	7.0	
	7.0	8.0	0.0	
Booth	S	25.0	8.0	6-24-78
	2.0	20.0	7.0	
	4.0	16.0	0.0	
D. Brost N.E.	S	26.5	8.0	7-19-78
	2.0	26.5	8.0	
	3.0	26.5	7.2	
	5.0	23.0	4.0	
D. Brost N.W.	S	24.0	7.8	7-20-78
	2.0	24.0	7.2	
	3.0	23.5	7.2	
	5.0	16.0	0.0	
	6.0	14.5	0.0	
D. Brost S.E.	S	24.0	7.0	7-19-78
	2.0	24.0	6.5	
	4.0	18.5	0.0	
H. Brost N.	S	26.0	9.0	7-8-78
	2.0	23.0	7.0	
	4.0	17.5	6.0	
H. Brost W.	S	26.0	9.0	7-6-78
	2.0	24.0	8.0	
	4.0	21.5	7.0	
Burgar	S	19.0	12.0	5-16-78
	2.0	18.0	11.0	
	4.0	14.0	11.0	

Appendix 7. (Continued)

Pond	Depth (m)	Temperature (C)	Dissolved oxygen (mg/l)	Date of collection
Calhoun	S	26.0	10.0	6-16-78
	2.0	23.0	9.0	
	4.0	19.0	5.0	
	5.5	13.0	2.0	
Chamberlain	S	25.0	6.0	7-18-78
	2.0	23.0	5.0	
	4.0	22.0	2.0	
Daum	S	23.0	9.0	7-9-78
	2.0	23.0	9.0	
	4.0	21.0	8.0	
	5.0	19.0	8.0	
Deutsch	S	28.5	9.0	7-17-78
	2.0	23.5	9.0	
	4.0	18.0	0.0	
Dykstra	S	24.0	8.0	7-11-78
	2.0	23.0	8.0	
	4.0	23.0	7.0	
Eckerman	S	24.0	7.0	6-29-78
	2.0	23.0	7.0	
	4.0	19.5	7.0	
Eide	S	25.0	11.0	6-29-78
	2.0	22.0	6.0	
	4.0	16.0	0.0	
	6.0	13.8	0.0	
	7.0	13.0	0.0	
Frantz E.	S	27.0	10.0	6-14-78
	2.0	22.0	9.0	
	4.0	17.0	9.0	
Frantz W.	S	24.0	9.0	6-15-78
	2.0	21.5	9.0	
	3.5	16.0	5.0	
Fronek	S	25.0	7.0	7-18-78
	2.0	23.0	5.0	
	3.5	20.0	0.0	

Appendix 7. (Continued)

Pond	Depth (m)	Temperature (C)	Dissolved oxygen (mg/l)	Date of collection
Glynn	S	20.0	5.5	6-8-78
	2.0	18.5	0.0	
	4.0	15.5	0.0	
Iverson	S	21.0	8.0	7-11-78
	2.0	21.0	7.0	
	4.0	21.0	7.0	
	5.0	21.0	7.0	
Kinsley	S	24.0	15.5	6-5-78
	2.0	17.5	15.0	
	4.0	16.0	12.0	
Lantz	S	23.0	10.0	6-16-78
	2.0	21.5	9.0	
	4.0	18.0	5.0	
	6.0	15.5	2.0	
G. Mayer	S	23.0	8.0	6-17-78
	2.0	21.0	8.0	
	4.0	19.5	2.0	
J. Mayer N.	S	20.0	7.0	6-9-78
	2.0	19.0	7.0	
	3.0	18.0	5.5	
J. Mayer W.	S	20.0	7.0	6-9-78
	2.0	17.5	8.0	
	4.0	15.0	2.0	
	5.0	14.0	0.0	
National Grassland N.	S	24.0	8.0	8-9-78
	2.0	22.0	7.0	
	4.0	20.0	0.0	
National Grassland S.	S	23.0	9.0	8-9-78
	2.0	22.0	8.0	
	4.0	20.0	0.0	
Olson	S	25.0	8.0	6-6-78
	2.0	21.0	7.5	
	4.0	18.0	6.0	

Appendix 7. (Continued)

Pond	Depth (m)	Temperature (C)	Dissolved oxygen (mg/l)	Date of collection
Osnes	S	22.5	6.0	6-27-78
	2.0	19.5	4.0	
	4.0	18.8	2.0	
Perry	S	24.0	9.0	6-25-78
	2.0	23.0	9.0	
	4.0	22.0	7.0	
Peterson	S	21.0	8.0	6-15-78
	2.0	21.0	8.0	
	4.0	18.0	7.0	
	5.0	17.0	3.0	
Pistulka E.	S	28.0	10.0	6-27-78
	2.0	21.5	9.0	
	3.5	19.0	0.0	
Pistulka N.	S	23.5	7.0	6-28-78
	2.0	19.8	5.0	
	4.0	13.0	0.0	
Rasmussen	S	21.5	10.0	6-7-78
	2.0	18.0	5.5	
	4.0	14.0	0.0	
Reur	S	27.0	8.0	8-7-78
	2.0	22.0	8.5	
	3.0	21.5	7.5	
	4.5	20.5	6.0	
Rust	S	23.0	7.0	7-10-78
	2.0	22.0	7.0	
	4.0	21.0	6.0	
	5.0	19.0	2.0	
Sivage	S	25.0	9.0	8-10-78
	2.0	24.0	8.0	
	4.0	21.0	6.5	
	6.0	17.0	0.0	
Smikle	S	25.0	9.5	6-26-78
	2.0	21.0	6.0	
	4.0	18.0	1.0	

Appendix 7. (Continued)

Pond	Depth (m)	Temperature (C)	Dissolved oxygen (mg/1)	Date of collection
D. Smith N.	S	24.0	8.0	8-8-78
	2.0	22.0	8.0	
	4.0	21.0	7.0	
D. Smith S.	S	23.0	8.5	8-8-78
	2.0	23.0	8.5	
	4.0	21.0	8.0	
	6.0	18.0	0.0	
L. Smith	S	21.0	7.5	5-24-78
	2.0	20.0	7.5	
	4.0	18.0	7.5	
	6.0	16.0	4.0	
Wellman	S	24.0	7.0	7-10-78
	2.0	23.0	6.0	
	4.0	22.0	4.0	
	5.5	21.0	0.0	
Wilinski	S	20.0	11.0	5-17-78
	2.0	20.0	10.0	
	3.5	20.0	9.0	
Wilson	S	21.5	7.0	7-10-78
	2.0	21.5	6.0	
	4.0	19.5	4.0	
	5.0	16.5	0.0	

[a]Surface

[b]Bottom

Appendix 8. Water chemistry data in 18 stock ponds in south-central South Dakota during summer 1977.

Pond	pH	Specific[a] conductance μmho/cm	Total hardness (mg/l as $CaCO_3$)	Total alkalinity (mg/l as $CaCO_3$)	Date
Baughman	8.5	249	130	90	7-27-77
Booth	8.7	273	100	70	7-28-77
H. Brost E.	8.2	709	220	60	8-6-77
H. Brost N.	8.7	488	200	60	8-5-77
H. Brost W.	8.4	709	210	60	8-4-77
Burgar	8.1	820	210	110	8-9-77
Daum	8.1	1513	700	90	10-8-77
Dykstra	8.0	675	200	90	10-9-77
Frantz	7.8	1898	300	70	8-12-77
Kinsley	6.9	416	300	90	10-11-77
National Grassland N.	7.6	492	150	120	7-21-77
National Grassland S.	7.0	820	300	130	7-20-77
Reur	8.7	945	150	90	8-11-77
Sargent	8.7	630	200	70	7-31-77
D. Smith N.	7.1	1452	500	110	7-30-77
D. Smith S.	7.8	1050	440	70	7-29-77
L. Smith	6.5	805	250	120	7-19-77
Wilinski	7.2	1907	860	90	8-10-77

[a]Corrected to 25 C

Appendix 9. Water chemistry data in 45 stock ponds in south-central South Dakota during summer 1978.

Pond	pH	Specific[a] conductance μmho/cm	Total hardness (mg/l as $CaCO_3$)	Total alkalinity (mg/l as $CaCO_3$)	Date
Ambur	7.8	738	300	50	6-28-78
Baughman	7.3	150	60	40	5-18-78
Booth	8.0	220	110	100	6-24-78
D. Brost N.E.	8.6	885	290	130	7-19-78
D. Brost N.W.	8.9	646	260	90	7-20-78
D. Brost S.E.	9.2	697	190	60	7-19-78
H. Brost N.	9.0	478	150	70	7-8-78
H. Brost W.	9.3	1384	450	100	7-6-78
Burgar	7.7	1725	390	120	5-16-78
Calhoun	11.0	673	110	25	6-16-78
Chamberlain	8.8	170	80	60	7-18-78
Daum	9.3	2856	750	110	7-9-78
Deutsch	9.2	201	110	60	7-17-78
Dykstra	8.8	893	350	80	7-11-78
Eckerman	7.8	214	120	100	6-29-78
Eide	8.8	300	230	120	6-29-78
Frantz E.	11.0	855	140	30	6-14-78
Frantz W.	9.3	1322	210	30	6-15-78
Fronek	9.7	240	100	80	7-18-78
Glynn	7.2	259	120	150	6-8-78
Iverson	9.2	1540	690	75	7-11-78

Appendix 9. (Continued)

Pond	pH	Specific[a] conductance µmho/cm	Total hardness (mg/l as $CaCO_3$)	Total alkalinity (mg/l as $CaCO_3$)	Date
Kinsley	10.0	354	300	90	6-5-78
Lantz	9.6	307	140	40	6-16-78
G. Mayer	9.6	357	130	110	6-17-78
J. Mayer N.	7.8	245	120	100	6-9-78
J. Mayer W.	8.1	248	90	140	6-9-78
National Grassland N.	9.2	292	150	80	8-9-78
National Grassland S.	8.8	977	340	110	8-9-78
Olson	7.7	820	250	50	6-6-78
Osnes	7.8	244	130	100	6-27-78
Perry	7.8	933	300	110	6-25-78
Peterson	9.2	220	100	20	6-15-78
Pistulka E.	10.2	305	130	30	6-27-78
Pistulka N.	7.2	988	250	170	6-27-78
Rasmussen	9.3	239	50	15	6-7-78
Reur	8.9	845	120	80	8-7-78
Rust	9.0	210	100	60	7-10-78
Sivage	9.2	580	150	80	8-10-78
Smikle	11.0	500	150	20	6-26-78
D. Smith N.	9.2	292	150	80	8-9-78
D. Smith S.	9.0	1344	560	90	8-8-78

Appendix 9. (Continued)

Pond	pH	Specific[a] conductance µmho/cm	Total hardness (mg/l as $CaCO_3$)	Total alkalinity (mg/l as $CaCO_3$)	Date
L. Smith	7.8	550	200	120	6-8-78
Wellman	8.8	215	140	70	7-9-78
Wilinski	7.2	2025	890	70	5-17-78
Wilson	8.9	163	120	30	7-10-78

[a]Corrected to 25 C